

A COMPLETE
SYSTEM OF PYROTECHNY,
OR THE
Art of making Fire-Works.



IN the art of making fire-works, great attention must be paid to the well mixing of the materials, without which all labour is thrown away, to the purity of the articles, and to the proper quantities of each. Sulphur, to be good, must be of a high colour, and crack and bounce when held in the hand. For small fire-works, such as may be bought in the the flour will be found quite good enough, but for the larger kinds, the lump brimstone ground is preferable.

Benjamin is used in fire-works, more for its pleasant scent than any material use for the purposes of fire. It may be procured at the chemists' ready for use. The oil is also used in wet composition, for stars, &c.



Of Sulphur, or Brimstone.

SULPHUR is by nature the food of fire, and one of the principal ingredients in gunpowder, and almost in all compositions of fire-works; therefore great care ought to be taken of its being good, and brought to the highest perfection. Now, to know when the sulphur is good, you are to observe that it be of a high yellow, and if, when held in one's hand, it crackles and bounces, it is a sign that it is fresh and good; but as the method of reducing brimstone to a powder is very troublesome, it is better to buy the flower ready-made, which is done in large quantities, and in great perfection; but when a great quantity of fire-works is to be made, it best to use the lump brimstone ground, in the same manner as gunpowder.



Of Saltpetre.

SALTPETRE being the principle ingredient in fire-works, and a volatile body, by reason of its aqueous and aerial parts, is easily rarified by fire; but not so soon when foul and gross, as when purified from its gross and earthy parts, which greatly retard its velocity; therefore, when any quantity of fireworks is intended to be made, it would be necessary first to examine the saltpetre; for if it be not well cleansed from all impurities, and of a good sort, your works will not have their proper effect,

To pulverize Saltpetre.

TAKE a copper kettle, the bottom being spherical, and put into it fourteen pounds of refined saltpetre, with two quarts or five pints of clean water; then put the kettle on a slow fire, and when the saltpetre is dissolved, if any impurities arise, skim them off, and keep constantly stirring it with two large spatulas, till all the water exhales; and when done enough, it will appear like white sand, and as fine as flour; but if it should boil too fast, take the kettle off the fire, and set it on some wet sand, which will prevent the nitre from sticking to the kettle. When you have pulverized a quantity of saltpetre, be careful to keep it in a dry place.

To prepare Charcoal for Fireworks.

CHARCOAL is a preservative, by which the saltpetre and brimstone are made into gunpowder, by preventing the sulphur from suffocating the strong and windy exhalation of the nitre. There are several sorts of wood made use of for this purpose; some prefer hazel, others willow, and others alder. The method of burning the wood is this: cut it in pieces of two or three feet long, then slit each piece in four parts; scale off the bark and hard knots, and dry them in the sun, or in an oven; then make in the earth a square hole, and line it with bricks, in which lay the wood crossing one another, and set it on fire; when

thoroughly lighted, and in a flame, cover the hole with boards, and fling earth over them close, to prevent the air from getting in, yet so as not to fall among the charcoal; and when it has lain thus for twenty-four hours, take out the coals and lay them in a dry place for use. It is to be observed that charcoal for fire-works must always be soft and well burnt, which may be bought ready done.

Of Gunpowder, &c.

GUNPOWDER being a principal ingredient in fire-works, it will not be improper to give a short definition of its strange explosive force, and cause of action, which, according to Dr. Shaw's opinion of the chemical cause of the explosive force of gunpowder, is as follows:—Each grain of gunpowder consisting of a certain proportion of sulphur, nitre, and coal, the coal presently takes fire, upon contact of the smallest spark; at which time both the sulphur and the nitre immediately melt, and by means of the coal interposed between them, burst into flame; which spreading from grain to grain, propagates the same effect almost instantaneously, whence the whole mass of powder comes to be fired; and as nitre contains a large proportion both of air and water, which are now violently rarified by the heat, a kind of fiery explosive blast is thus produced, wherein the nitre seems, by its aqueous and aerial parts, to act as bellows to the other inflammable bodies (sulphur and coal) to blow them into a flame, and carry off their whole substance in smoke and vapour."

How to meal Gunpowder, Brimstone, and Charcoal.

THERE have been many methods used to grind these ingredients to a powder for fire-works, such as large mortars and pestles made of ebony, and other hard woods; but none of these methods have proved so effectual and speedy as the last invention, that of the mealing table. This table is made of elm, with a rim round its edge, four or five inches high; and at the narrow end is a slider, which runs in a

groove and forms part of the rim; so that when you have taken out of the table as much powder as you conveniently can, with a copper shovel, you may sweep all clean out at the slider. When you are going to meal a quantity of powder, observe not to put too much on the table at once; but when you have put in a good proportion, take a muller and rub it therewith till all the grains are broken; searce it in a lawn sieve, that has a receiver and top to it; and that which does not pass through the sieve, return again to the table and grind it more, till you have brought it all fine enough to go through the sieve. Brimstone and charcoal are ground in the same manner as gunpowder, only the muller must be made of ebony, for these ingredients being harder than powder, would stick in the grain of the elm, and be very difficult to grind; and as the brimstone is apt to stick and clog to the table, it would be best to keep one for that purpose only, by which means you will always have your brimstone clean and well ground.

Spur Fire.

THIS fire is the most beautiful of any composition yet known. As it requires great trouble to bring it to perfection, particular care must be paid to the following instructions. They are made generally in cases about six inches long, but not driven very hard.

CHARGE.	lb.	oz.		CHARGE.	lb.	oz.
Saltpetre	4	0	} or {	Saltpetre	1	0
Sulphur	2	0		Sulphur	0	8
Lamp-black	1	8		Lamp-black....	4	quarts.

This composition is very difficult to mix. The saltpetre and brimstone must be first sifted together, and then put into a marble mortar, and the lamp-black with them, which you work down by degrees with a wooden pestle, till all the ingredients appear of one colour, which will be something greyish, but very near black: then drive a little into a case for trial, and fire it in a dark place; and if the sparks, which are called stars, or pinks, come out in clusters, and afterwards spread well without any other sparks, it is a sign of its being good, otherwise, not; for if any drossy sparks ap-

pear, and the stars not full, it is then not mixed enough; but if the pinks are very small, and soon break, it is a sign that you have rubbed it too much.

This mixture when rubbed too much, will be too fierce, and hardly show any stars; and, on the contrary, when not mixed enough, will be too weak, and throw out an obscure smoke, and lumps of dross, without any stars. The reason of this charge being called the spur fire is, because the sparks it yields have a great resemblance to the rowel of a spur, from whence it takes its name. As the beauty of this composition cannot be seen at so great a distance as brilliant fire, it has a better effect in a room than in the open air, and may be fired in a chamber without any danger: it is of so innocent a nature, that, although an improper phrase, it may be called a cold fire; and so extraordinary is the fire produced from this composition, that, if well made, the sparks will not burn a handkerchief when held in the midst of them; you may hold them in your hand while burning with as much safety as a candle; and if you put your hand within a foot of the case, you will feel the sparks fall like drops of rain.

To make Touch Paper.

DISSOLVE in some spirits of wine or vinegar, a little saltpetre; then take some purple or blue paper, wet it with the above liquor, and when dry it will be fit for use. When you paste this paper on any of your works, take care that the paste does not touch that part which is to burn. The method of using this paper is, by cutting it into slips, long enough to go once round the mouth of the serpent, cracker, &c. When you paste on these slips, leave a little above the mouth of the case not pasted; then prime the case with meal powder, (see p. 177) and twist the paper to a point.

Of such Ingredients as show themselves in Sparks when rammed into choaked Cases.

THE set colours of fire produced by sparks are divided into four sorts, viz. the black, white, grey, and red; the black charges are composed of two ingredients, which are meal powder and charcoal; the white of three, viz. saltpetre, sulphur, and charcoal; the grey of four, viz. meal powder, saltpetre, brimstone, and charcoal; and the red of three, viz. meal powder, charcoal, and saw-dust.

There are, beside these four regular or set charges, two others, which are distinguished by the names of compound and brilliant charges; the compound charge being made of many ingredients, such as meal powder, saltpetre, brimstone, charcoal, saw-dust, sea-coal, antimony, glass-dust, brass-dust, steel-filings, cast-iron, tanners' dust, &c. or any thing that will yield sparks; all which must be managed with discretion. The brilliant fires are composed of meal powder, saltpetre, brimstone, and steel-dust; or with meal-powder and steelfilings only.

Of the Method of mixing Compositions.

THE performance of the principal part of fire-works depends much on the compositions being well mixed; therefore great care ought to be taken in this part of the work, particularly in the composition for sky-rockets. When you have four or five pounds of ingredients to mix, which is a sufficient quantity at a time, (for a larger proportion will not do so well) first put the different ingredients together, then work them about with your hands, till you think they are pretty well incorporated; after which put them into a lawn sieve with a receiver and top to it; and if, after it is sifted, any should remain that will not pass through the sieve, grind it again till fine enough; and if it be twice sifted it will not be amiss; but the compositions for wheels and common works are not so material, nor need be so fine. But in all fixed works, from which the fire is to play regular, the ingredients must be very fine, and great care taken in mixing them well together: and

observe, that, in all compositions wherein are steel or iron filings, the hands must not touch; nor will any works, which have iron or steel in their charge, keep long in damp weather, without being properly prepared; according to the following directions:

It may sometimes happen, that fireworks may be required to be kept a long time, or sent abroad; neither of which could be done with brilliant fires, if made with filings unprepared; for this reason, that the saltpetre being of a damp nature, it causes the iron to rust, the natural consequence of which is, that when the works are fired, there will appear but very few brilliant sparks, but instead of them a number of red and drossy sparks; and besides, the charge will be so much weakened, that if this should happen to wheels, the fire will not be strong enough to force them round; to prevent such accidents, prepare your filings after the following manner:—Melt in a glazed earthen pan some brimstone over a slow fire, and when melted, throw in some filings, which keep stirring about till they are covered with brimstone; this you must do while it is on the fire; then take it off, and stir it very quick till cold, when you must roll it on a board with a wooden roller, till you have broken it as fine as corn powder; after which, sift from it as much of the brimstone as you can. There is another method of preparing filings, so as to keep two or three months in winter; this may be done by rubbing them between the strongest sort of brown paper, which has been previously moistened with linseed oil.

N. B. If the brimstone should take fire, you may put it out, by covering the pan close at top. It is not of much consequence what quantity of brimstone you use, provided there is enough to give each grain of iron a coat; but as much as will cover the bottom of a pan of about one foot diameter, will do for five or six pounds of filings. Cast-iron for gerbes will be preserved by the above method.

To make Crackers.

Cut some stout cartridge-paper into pieces three inches and a half broad, and one foot long; one edge of each of

these pieces fold down lengthwise about three quarters of an inch broad; then fold the double edge down a quarter of an inch, and turn the single edge back half over the double fold; open it, and lay all along the channel, which is formed by the foldings of the paper, some meal-powder; then fold it over and over till all the paper is doubled up, rubbing it down every turn; this being done, bend it backwards and forwards, two inches and a half, or thereabouts, at a time, as often as the paper will allow; hold all these folds flat and close, and with a small pinching cord, give one turn round the middle of the cracker, and pinch it close; bind it with packthread, as tight as you can; then in the place where it was pinched, prime one end, and cap it with touch-paper. When these crackers are fired, they will give a report at every turn of the paper; if you would have a great number of bounces, you must cut the paper longer, or join them after they are made; but if they are made very long before they are pinched, you must have a piece of wood with a groove in it, deep enough to let in half the cracker; this will hold it straight while it is pinching.

To make Squibs and Serpents.

FIRST make the cases, of about six inches in length, by rolling slips of stout cartridge-paper three times round a roller, and pasting the last fold; tying it near the bottom as tight as possible, and making it air-tight at the end by sealing-wax. Then take of gunpowder half a pound, charcoal one ounce, brimstone, one ounce, and steel-filings half an ounce, (or in like proportion) grind them with a muller, or pound them in a mortar. Your cases being dry and ready, first put a thimble-full of your powder, and ram it hard down with a ruler; then fill the case to the top with the aforesaid mixture, ramming it hard down in the course of filling two or three times; when this is done, point it with touch-paper, which should be pasted on that part which touches the case, otherwise it is liable to drop off.

Sky Rockets.

ROCKETS being of the fire-works most in use, we shall give them the preference in description. As the performance of rockets depends much upon their moulds, they should be made according to the following proportions:—Taking the diameter of the orifice, its height should be equal to six diameters and two-thirds; the choke, one diameter and one-third of this model, will serve for every rocket from 4 oz. to 6 lb. For instance; suppose the diameter of a rocket of 11lb. be $1\frac{1}{2}$ inch, then its length being 6 diameters and two-thirds, the length of the case must be $10\frac{1}{4}$ inches, and the choke $2\frac{1}{4}$ inches. Your rammer must have a collar of brass to prevent the wood from splitting.

Method of rolling Rocket Cases.—The cases must be made of the strongest cartridge paper, and rolled dry. The case of a middling sized rocket will take up paper of four or five sheets thick; having cut your papers to a proper size, and the last sheet with a slope at one end, fold down one end, and lay your former on the double edge, and when you have rolled on the paper within two or three turns, lay the next sheet on that part which is loose, and roll it all on. Then, in order to roll the case as hard as possible, place it on a table, and with a smooth board roll it for some time forwards on the table till it becomes quite hard and firm. This must be done with every sheet. You have next to choak the case, for which purpose draw your former a little distance from the bottom, then, with a cord once round the case, pull it rather easy at first, and harder, till you have closed the end. To make it easy, you may dip the ends of the inner sheets in water before rolling, then bind it with small twine.

Having thus pinched and tied the case so as not to give way, put it into the mould without its foot, and with a mallet drive the former hard on the end-piece, which will force the neck close and smooth. This done, cut the case to its proper length, allowing from the neck to the edge of the mouth half a diameter, which is equal to the height of the nipple; then take out the former, and drive the case over the piercer with a long rammer, and the vent will be of a proper size.

Having formed your cases, we will now proceed to the description of the ingredients necessary for the rocket.

Of mixing the Composition.—The performance of the principal part of fire-works depends much on the compositions being well mixed, therefore, great care must be taken in this part of the work, particularly for the composition for sky-rockets. When you have four or five pounds of ingredients to mix, which is a sufficient quantity at a time, for a larger proportion will not do so well) first put the different ingredients together, then work them about with your hands, till you think they are pretty well incorporated; after which, put them into a lawn sieve with a receiver and top to it; and if, after it is sifted, any remains that will not pass through the sieve, grind it again till it is fine enough; and if it be twice sifted, it will not be amiss, but the compositions for wheels and common works are not so material, nor need be so fine. But in all fixed works, from which the fire is to play regular, the ingredients must be very fine, and great care taken in mixing them well together; and observe, that in all compositions wherein are iron filings, the hand must not touch them; nor will any works which have iron or steel in their charge keep long in damp weather.

To drive or ram Rockets.—Rockets are filled hollow, otherwise they would not ascend, and there is not a part that requires greater attention than this stage of the process. One blow more or less with the mallet will spoil the ascent.

The charge of rockets must always be driven above the piercer, and on it must be rammed a thin head of clay; through the middle of which bore a small hole to the composition, that when the charge is burnt to the top, it may communicate its fire through the hole to the stars in the head.

To a rocket of four ounces, give to each ladle-full of charge 16 strokes; to a rocket of 1 lb. 28; to a 2-pounder, 36; to a 4-pounder, 42; and to a 6-pounder, 56; but rockets of a larger sort cannot be driven well by hand, but must be rammed with a machine made in the same manner as those for driving piles.

The method of ramming wheel cases, or any other sort in which the charge is driven solid, is the same as sky-rockets.

When you load the heads of your rockets with stars, rains, serpents, crackers, scrolls, or any thing else, according to your fancy, remember always to put a ladleful of meal-powder into each head, which will be enough to burst the head, and disperse the stars, or whatever it contains.

Decorations for Shy Rockets.—Sky-rockets may be decorated according to fancy. Some are headed with stars of different sorts, such as tailed, brilliant, white, blue, and yellow stars, &c. Some with gold and silver rains; others with serpents, crackers, fire-scrolls, and maroons; and some with small rockets and other devices, as the maker pleases.

LENGTH OF ROCKET STICKS.

For rockets of 6 lb.	0 oz.	the stick must be 14 ft. 10 in. long	
4	0	12	10
2	0	9	4
1	0	8	2
0	8	6	6
0	4	5	3

Having your sticks ready, cut on one of the flat sides at the top a groove the length of the rocket, and as broad as the stick will allow; then on the opposite flat side, cut two notches, for the cord, which ties on the rocket, to lie in; one of these notches must be near the top of the stick, and the other facing the neck of the rocket; the distance between these notches may be easily known, for the top of the stick should always touch the head of the rocket. When your rockets and sticks are ready, lay the rockets in the grooves in the sticks, and tie them on. We will now proceed to the charge for sky-rockets:

ROCKETS OF FOUR OUNCES.

	lb. oz.		lb. oz.
Meal-powder	1 4	Charcoal	0 2
Saltpetre	0 4		

ROCKETS OF EIGHT OUNCES.

	lb. oz.		lb. oz.
Meal-powder	1 0	Brimstone	0 3
Saltpetre	0 4	Charcoal	0 1½

ONE POUND.

	lb. oz.		lb. oz.
Meal-powder	2 0	Charcoal	0 2
Saltpetre	0 8	Steel-filings	0 1½
Brimstone	0 4		

SKY-ROCKETS IN GENERAL.

	lb. oz.		lb. oz.
Saltpetre	4 0	Charcoal	1 12
Brimstone.....	1½ 0	Meal-powder	0 2

LARGE SKY-ROCKETS.

	lb. oz.		lb. oz.
Saltpetre	4 0	Brimstone.....	1 0
Meal-powder	1 0		

ROCKETS OF A MIDDLING SIZE.

	lb. oz.		lb. oz.
Meal-powder	1 0	Saltpetre	3 0
Charcoal	1 0	Sulphur.....	2 0

ROCKET STARS.

WHITE STARS.

	lb. oz.		lb. oz.
Meal-powder	0 4	Oil of spike	0 2
Saltpetre	0 12	Camphor	0 5
Sulphur vivum	0 6		

BLUE STARS.

	lb. oz.		lb. oz.
Meal-powder	0 8	Spirits of wine	0 2
Saltpetre	0 4	Oil of spike	0 2
Sulphur.....	0 2		

VARIEGATED STARS.

	lb. oz.		lb. oz.
Meal-powder	0 0½	Sulphur vivum	0 2
Saltpetre	0 4	Camphor	0 2

BRILLIANT STARS.

	lb. oz.		lb. oz.
Saltpetre	0 3½	Meal-powder	0 0¼
Sulphur	0 1½		

Worked up with spirits of wine only.

COMMON STARS.

	lb. oz.		lb. oz.
Saltpetre	1 0	Isinglass	0 0½
Brimstone	0 4	Camphor.....	0 0¼
Antimony	0 4½	Spirits of wine	0 0½

TAILED STARS.

	lb. oz.		lb. oz.
Meal-powder	0 2	Saltpetre	0 2
Brimstone	0 2	Charcoal (coarsely ground)	0 0 $\frac{1}{4}$

STARS OF A FINE COLOUR.

	lb. oz.		lb. oz.
Sulphur.....	0 1	Camphor.....	0 0 $\frac{1}{4}$
Meal-powder	0 1	Oil of turpentine ..	0 0 $\frac{1}{4}$
Saltpetre	0 1		

RAINS.

GOLD RAIN FOR SKY-ROCKETS.

	lb. oz.		lb. oz.
Saltpetre	0 8	Antimony	0 0 $\frac{1}{4}$
Brimstone.....	0 2	Brass-dust	0 0 $\frac{1}{4}$
Glass-dust.....	0 1	Saw dust.....	0 0 $\frac{1}{4}$

SILVER RAIN.

	lb. oz.		lb. oz.
Saltpetre	0 8	Charcoal	0 4
Brimstone.....	0 2	Steel-dust	0 0 $\frac{1}{4}$

To fix one Rocket on the top of another.—When sky-rockets are fixed one on the top of another, they are called *towering rockets*, on account of their mounting so very high. Towering rockets are made after this manner: Fix on a pound-rocket a head without a collar; then take a four ounce rocket, which may be headed or bounced, and rub the mouth of it with meal-powder wetted with spirit of wine: this done, put it in the head of the large rocket with its mouth downwards; but before it is put in, stick a bit of quick-match in the hole of the clay of the pound-rocket, which match should be long enough to go a little way up the bore of the small rocket, to fire it when the large rocket is burnt out. As the four ounce rocket is too small to fill the head of the other, roll round it as much tow as will

make it stand upright in the centre of the head: the rocket being thus fixed, paste a single paper round the opening of the top of the head of the large rocket. The large rocket must have only half a diameter of charge rammed above the piercer; for, if filled to the usual height, it would turn before the small one takes fire, and entirely destroy the intended effect: when one rocket is headed with another, there will be no occasion for any blowing powder; for the force with which it goes off will be sufficient to disengage it from the head of the first fired rocket. The sticks for these rockets must be a little longer than for those headed with stars, rains, &c.

Caduceus Rockets.—They are such as, in rising, form two spiral lines, by reason of their being placed obliquely, one opposite to the other; and their counterpoise in the centre, which causes them to rise in a vertical direction. Rockets for this purpose must have their ends choaked close, without either head or bounce, for a weight at top would be a great obstruction to their mounting. No caduceus rockets ascend so high as single, because of their serpentine motion, and likewise the resistance of air, which is much greater than two rockets of the same size would meet with if fired singly.

The sticks for this purpose must have all their sides equal, and the sides should be equal to the breadth of a stick proper for a sky-rocket of the same weight as those you intend to use, and made to taper downwards as usual, long enough to balance them, one length of a rocket from the cross stick; which must be placed from the large stick six diameters of one of the rockets, and its length seven diameters; so that each rocket, when tied on, may form with the large stick an angle of 60 degrees. In tying on the rockets, place their heads on the opposite sides of the cross stick, and their ends on the opposite sides of the long stick; then carry a leader from the mouth of one into that of the other. When these rockets are to be fired, suspend them between two hooks or nails, then burn the leader through the middle, and both will take fire at the same time. Rockets of 1 lb. are a good size for this use.

Honorary Rockets.—These are the same as sky-rockets, except that they carry no head nor report, but are closed

at top, on which is fixed a cone: then on the case, close to the top of the stick is tied on a two ounce case, about five or six inches long, filled with a strong charge, and pinched close at both ends; then in the reverse sides, at each end, bore a hole in the same manner as in tourbillons, to be presently described; from each hole carry a leader into the top of the rocket. When the rocket is fired, and arrived to its proper height, it will give fire to the case at top; which will cause both rocket and stick to spin very fast in their return, and represent a worm of fire descending to the ground.

There is another method of placing the small case, which is by letting the stick rise a little above the top of the rocket, and tying the case to it, so as to rest on the rocket; these rockets have no cones.

A third method by which they are managed, is this: In the top of a rocket fix a piece of wood, in which drive a small iron spindle; then make a hole in the middle of the small case, through which put the spindle: then fix on the top of it a nut, to keep the case from falling off; when this is done, the case will turn very fast, without the rocket: but this method does not answer so well as either of the former.

To make a Rocket form an Arch in rising.—Having some rockets made, headed according to fancy, and tied on their sticks, get some sheet tin, and cut it into round pieces about three or four inches diameter; then on the stick of each rocket, under the mouth of the case, fix one of these pieces of tin 16 inches from the rocket's neck, and support it by a wooden bracket, as strong as possible: the use of this is, that when the rocket is ascending, the fire may play with great force on the tin, which will divide the tail in such a manner that it will form an arch as it mounts, and will have a very good effect when well managed: if there is a short piece of port-fire, of a strong charge, tied to the end of the stick, it will make a great addition; but this must be lighted before the rocket is fired.

To make several Rockets rise together.—Take six, or any number of sky-rockets, of any size; then cut some strong packthread into pieces of three or four yards long, and tie each end of these pieces to a rocket in this manner.

Having tied one end of the packthread round the body of one rocket, and the other end to another, take a second piece of packthread, and make one end of it fast to one of the rockets already tied, and the other end to a third rocket, so that all the rockets, except the two on the outside, will be fastened to two pieces of packthread: the length of thread from one rocket to the other may be what the maker pleases; but the rockets must be all of a size, and their heads filled with the same weight of stars, rains, &c.

Having thus done, fix in the mouth of each rocket a leader of the same length; and when about to fire them, hang them almost close; then tie the ends of the leaders together and prime them. This prime being fired, all the rockets will mount at the same time, and divide as far as the strings will allow; and this division they will keep, provided they are all rammed alike, and well made. They are sometimes called *chained rockets*.

To fix several Rockets to the same Stick.—Two, three, or six sky-rockets, fixed on one stick, and fired together, make a grand and beautiful appearance: for the tails of all will seem but as one of an immense size; and the breaking of so many heads at once will resemble the bursting of an air-balloon. The management of this device requires a skilful hand; but if the following instructions be well observed, even by those who have not made a great progress in this art, there will be no doubt of the rockets having the desired effect.

Rockets for this purpose must be made with the greatest exactness, rammed by the same hand, in the same mould, and filled with the same proportion of composition; and after they are filled and headed, must all be of the same weight. The stick must also be well made (and proportioned) to the following directions: first, supposing the rockets to be half-pounders, whose sticks are six feet six inches long, then if two, three, or six of these are to be fixed on one stick, let the length of it be nine feet nine inches: then cut the top of it into as many sides as there are rockets, and let the length of each side be equal to the length of one of the rockets without its head; and in each side cut a groove as (usual); then from the grooves plane

it round, down to the bottom, where its thickness must be equal to half the top of the round part. As their thickness cannot be exactly ascertained, we shall give a rule which generally answers for any number of rockets above two: the rule is this; that the stick at top must be thick enough, when the grooves are cut, for all the rockets to lie, without pressing each other, though as near as possible.

When only two rockets are to be fixed on one stick, let the length of the stick be the last given proportion, but shaped after the common method, and the breadth and thickness double the usual dimensions. The point of poise must be in the usual place (let the number of rockets be what it will): if sticks made by the above directions should be too heavy, plane them thinner; and if too light, make them thicker; but always make them of the same length.

When more than two rockets are tied on one stick, there will be some danger of their flying up without the stick, unless the following precaution is taken: For cases being placed on all sides, there can be no notches for the cord which ties on the rockets to lie in; therefore, instead of notches, drive a small nail in each side of the stick, between the necks of the cases; and let the cord, which goes round their necks, be brought close under the nails; by this means the rockets will be as secure as when tied on singly. The rockets being thus fixed, carry a quick-match, without a pipe, from the mouth of one rocket to the other; this match being lighted will give fire to all at once.

Though the directions already given may be sufficient for these rockets, we shall here add an improvement on a very essential part of this device, which is, that of hanging the rockets to be fired; for before the following method was contrived, many attempts proved unsuccessful. Instead, therefore, of the old and common manner of hanging them on nails or hooks, make use of the following contrivance: Have a ring made of strong iron wire large enough for the stick to go in as far as the mouths of the rockets; then have another ring supported by a small iron, at some distance from the post or stand to which it is fixed: then have another ring fit to receive and guide the small end of the stick. Rockets thus suspended will have nothing to

obstruct their fire; but when they are hung on nails or hooks, in such a manner that some of their mouths are against or upon a rail, there can be no certainty of their rising in a vertical direction.

To fire Rockets without Sticks. You must have a stand, of a block of wood, a foot diameter, and make the bottom flat, so that it may stand steady: in the centre of the top of this block draw a circle two inches and a half diameter, and divide the circumference of it into three equal parts; then take three pieces of thick iron wire, each about three feet long, and drive them into the block, one at each point made on the circle; when these wires are driven in deep enough to hold them fast and upright, so that the distance from one to the other is the same at top as at bottom, the stand is complete.

The stand being thus made, prepare the rockets thus: Take some common sky-rockets of any size, and head them as you please; then get some balls of lead, and tie to each a small wire two or two feet and a half long, and the other end of each wire tie to the neck of a rocket. These balls answer the purpose of sticks, when made of a proper weight, which is about two-thirds the weight of the rocket; but when they are of a proper size, they will balance the rocket in the same manner as a stick, at the usual point of poise. To fire these, hang them, one at a time, between the tops of the wires, letting their heads rest on the point of the wires, and the balls hang down between them: if the wires should be too wide for the rockets, press them together till they fit; and if too close, force them open; the wires for this purpose must be softened, so as not to have any spring, or they will not keep their position when pressed close or opened.

Scrolls for Rockets. Cases for scrolls should be made four or five inches in length, and their interior diameters three-eighths of an inch: one end of these cases must be pinched quite close before beginning to fill; and when filled, close the other end: then in the opposite sides make a small hole at each end, to the composition, as in tourbillons; and prime them with wet meal-powder. You may put in the head of a rocket as many of these cases as it will contain: being fired, they turn very quick in the air,

and form a scroll or spiral line. They are generally filled with a strong charge, as that of serpents or brilliant fire.

Stands for Rockets.—Care must be taken, in placing the rockets, when they are to be fired, to give them a vertical direction at their first setting out; which may be managed thus: Have two rails of wood, of any length, supported at each end by a perpendicular leg, so that the rails may be horizontal, and let the distance from one to the other be almost equal to the length of the sticks of the rockets intended to be fired; then in the front of the top rail drive square hooks at eight inches distance, with their points turned sideways, so that when the rockets are hung on them, the points will be before the sticks, and keep them from falling or being blown off by the wind; in the front of the rail at bottom must be staples, driven perpendicularly under the hooks at top; through these staples put the small ends of the rocket sticks. Rockets are fired by applying a lighted port-fire to their mouths.

Table Rockets.—Table rockets are designed merely to show the truth of driving, and the judgment of a fire-worker; they having no other effect, when fired, than spinning round in the same place where they begin, till they are burnt out, and showing nothing more than an horizontal circle of fire.

The method of making these rockets is,—Have a cone turned out of hard wood two inches and a half in diameter, and as much high; round the base of it drive a line; on this line fix four spokes, each two inches long, so as to stand one opposite the other; then fill four nine-inch one pound cases with any strong composition, within two inches of the top: these cases are made like tourbillons, and must be rammed with the greatest exactness.

The rockets being filled, fix their open ends on the short spokes: then in the side of each case bore a hole near the clay; all these holes, or vents, must be so made that the fire of each case may act the same way; from these vents, carry leaders to the top of the cone, and tie them together. When the rockets are to be fired, set them on a smooth table, and light the leaders in the middle, and all the cases will fire together and spin on the point of the cone.

These rockets may be made to rise like tourbillons, by

making the cases shorter, and boring four holes in the under side of each at equal distances: this being done, they are called *double tourbillons*.

Note.—All the vents in the under side of the cases must be lighted at once; and the sharp point of the cone cut off, at which place make it spherical.

WHEELS.

WHEEL cases are made to any length, which must always depend on the size of the wheel; but must not exceed the length of each angle.

Charge for wheel cases, from 2 oz to 4 lb.

	lb. oz.		lb. oz.
Meal-powder.....	4 0	Brimstone.....	0 8
Saltpetre	1 0	Charcoal	0 4

The filings in this composition may be varied by using a portion of sea-coal, glass-dust, saw-dust, &c. or a combination of the whole.

SLOW FIRE FOR WHEELS.

	lb. oz.		lb. oz.
Saltpetre	0 4	Meal-powder	0 1½
Brimstone.....	0 2	or,	

1 oz. of brimstone may be used with 1 oz. of antimony.

DEAD FIRE FOR WHEELS.

	oz. dr.		oz. dr.
Saltpetre	4½ 0	Lapis-caliminaris	0 2
Brimstone.....	0½ 0	Antimony	0 2

Single Vertical Wheels.—There are different sorts of vertical wheels; some having their fells of a circular form, others of an hexagonal, octagonal, or decagonal form, or of any number of sides, according to the length of the cases you design for the wheel: the spokes being fixed in the nave, nail slips of tin, with their edges turned up so as to form grooves for the cases to lie in, from the end of one spoke to that of another; then tie the cases in the grooves head to tail, in the same manner as those on the

horizontal water-wheel, so that the cases successively taking fire from one another, will keep the wheel in an equal rotation. Two of these wheels are very often fired together, one on each side of a building; and both lighted at the same time, and all the cases filled alike, to make them keep time together; as they will, if made by the following directions: in all the cases of both wheels, except the first, on each wheel drive two or three ladlesful of slow fire, in any part of the cases; but be careful to ram the same quantity in each case, and in the end of one of the cases, on each wheel, you may ram one ladleful of dead-fire composition, which must be very lightly driven; you may also make many changes of fire by this method.

Let the hole in the nave of the wheel be lined with brass, and made to turn on a smooth iron spindle. On the end of this spindle let there be a nut, to screw off and on; when you have put the wheel on the spindle, screw on the nut, which will keep the wheel from flying off. Let the mouth of the first case be a little raised. Vertical wheels are made from ten inches to three feet diameter, and the size of the cases must differ accordingly; four-ounce cases will do for wheels of 14 or 16 inches diameter, which is the proportion generally used. The best wood for wheels of all sorts, is a light and dry beech.

Horizontal Wheels.—They are best when their fells are made circular; in the middle of the top of the nave must be a pintle, turned out of the same piece as the nave, two inches long, and equal in diameter to the bore of one of the cases of the wheel: there must be a hole bored up the centre of the nave, within half an inch of the top of the pintle. The wheel being made, nail at the end of each spoke (of which there should be six or eight) a piece of wood, with a groove cut in it to receive the case. Fix these pieces in such a manner that half the cases may incline upwards and half downwards, and that, when they are tied on, their heads and tails may come very nearly together; from the tail of one case to the mouth of the other carry a leader, which should be secured with pasted paper. Besides these pipes, it will be necessary to put a little meal-powder within the pasted paper, to blow off the pipe, that there may be no obstruction to the fire from the

cases. By means of these pipes the cases will successively take fire, burning one upwards and the other downwards. On the pintle fix a case of the same sort as those on the wheel; this case must be fired by a leader from the mouth of the last case on the wheel, which case must play downwards: instead of a common case in the middle, you may put a case of Chinese fire, long enough to burn as long as two or three of the cases on the wheel.

Horizontal wheels are often fired two at a time, and made to keep time like vertical wheels, only they are made without any slow or dead fire; 10 or 12 inches will be enough for the diameter of wheels with six spokes.

Spiral Wheels.—They are only double horizontal wheels, and made thus: the nave must be about six inches long, and rather thicker than the single sort; instead of the pintle at top, make a hole for the case to be fixed in, and two sets of spokes, one set near the top of the nave, and the other near the bottom. At the end of each spoke cut a groove wherein you tie the cases, there being no fell; the spokes should not be more than two inches and a half long from the naves, so that the wheel may not be more than eight or nine inches diameter; the cases are placed in such a manner, that those at top play down, and those at bottom play up, but let the third or fourth case play horizontally. The case in the middle may begin with any of the others: six spokes will be enough for each set, so that the wheel may consist of 12 cases, besides that on the top: the cases six inches each.

Plural Wheels.—Plural wheels are made to turn horizontally, and to consist of three sets of spokes, placed six at top, six at bottom, and four in the middle, which last must be a little shorter than the rest: let the diameter of the wheel be 10 inches; the cases must be tied on the ends of the spokes in grooves cut on purpose, or in pieces of wood nailed on the ends of the spokes, with grooves cut in them as usual: in clothing these wheels, make the upper set of cases play obliquely downwards, the bottom set obliquely upwards, and the middle set horizontally. In placing the leaders, they must be managed so that the cases may burn thus, viz. first up, then down, then horizontal, and so on with the rest. But another change may be made, by

driving in the end of the eighth case two or three ladlesful of slow fire, to burn till the wheel has stopped its course; then let the other cases be fixed the contrary way, which will make the wheel run back again: for the case at top you may put a small gerbe; and let the cases on the spokes be short, and filled with a strong brilliant charge.

Illuminated Spiral Wheels.—First have a circular horizontal wheel made two feet diameter, with a hole quite through the nave; then take three thin pieces of deal, three feet long each, and three-fourths of an inch broad each: one end of each of these pieces nail to the fell of the wheel, at an equal distance from one another, and the other end nail to a block with a hole in its bottom, which must be perpendicular to that in the block of the wheel, but not so large. The wheel being thus made, have a hoop planed down very thin and flat; then nail one end of it into the fell of the wheel, and wind it round the three sticks in a spiral line from the wheel to the block at top: on the top of this block fix a case of Chinese fire; on the wheel you may place any number of cases, which must incline downwards, and burn two at a time. If the wheel should consist of ten cases, you may let the illuminations and Chinese fire begin with the second cases. The spindle for this wheel must be a little longer than the cone, and made very smooth at top, on which the upper block is to turn, and the whole weight of the wheel to rest.

Double Spiral Wheels.—For these wheels, the block or nave must be as long as the height of the worms, or spiral lines, but must be made very thin, and as light as possible. In this block must be fixed several spokes, which must diminish in length, from the wheel to the top, so as not to exceed the surface of a cone of the same height. To the ends of these spokes nail the worms, which must cross each other several times: clothe these worms with illuminations, the same as those on the single wheels; but the horizontal wheel you may clothe as you like. At the top of the worm place a case of spur-fire, on an amber light.

Balloon Wheels.—They are made to turn horizontally: they must be made two feet diameter, without any spokes; and very strong, with any number of sides. On the top of a wheel range and fix in pots, three inches diameter and

seven inches high each, as many of these as there are cases on the wheel: near the bottom of each pot make a small vent; into each of these vents carry a leader from the tail of each case; load some of the pots with stars, and some with serpents, crackers, &c. As the wheels turn, the pots will successively be fired, and throw into the air a great variety of fires.

BALLOON CASES.

You must have an oval former, turned of smooth wood; then paste a quantity of brown or cartridge paper, and let it lie till the paste has soaked all through; this done, rub the former with soap or grease, to prevent the paper from sticking to it; then lay the paper on in small slips, till you have made it one-third of the thickness of the shell intended. Having thus done, set it to dry; and when dry, cut it round the middle, leaving about one inch not cut, which will make the halves join much better than if quite separated. When you have some ready to join, place the halves even together, and let that dry; then lay on paper all over as before, every where equal. When the shell is thoroughly dry, burn a vent at top with a square iron.

Shells that are designed for stars only, may be made quite round, and the thinner they are at the opening the better; for if they are too strong, the stars are apt to break at the bursting of the shell. Balloons must always be made to go easy into the mortars.

MORTARS.

THESE mortars must be made of pasteboard with a small copper chamber at bottom, in which the powder is to be placed, on which the balloon is to be put. In the centre of the bottom of this chamber make a small hole a little down the foot: the hole must be met by another of the same size as the foot. Then putting a quick match, or touch-string, of touch-paper into the hole, your mortar will be ready to be fired.

To load Air Balloons with Stars, Serpents, &c. &c.—When you fill your shells, you must first put in the serpents,

rains, &c. or whatever they are composed of, then the blowing powder; but the shells must not be quite filled. All those things must be put in at the fuze hole, but marrons being too large to go into the fuze hole, must be put in before the inside is joined. When the shells are loaded, glue and drive in the fuzes very tight. The number and quantities of each article for the different shells are as follow:

BALLOONS ILLUMINATED.

	oz.		oz.
Meal-powder.....	1	Powder for the mortar ..	2
Corn-powder.....	0½		

BALLOONS OF SERPENTS.

	oz.		oz.
Meal-powder	1	Powder for the mortar ..	2½
Corn-powder	1		

Aigrettes.

MORTARS to throw aigrettes are generally made of pasteboard, of the same thickness as balloon mortars, and two diameters and a half long in the inside from the top of the foot: the foot must be made of elm without a chamber, but flat at top, and in the same proportion as those for balloon mortars; these mortars must also be bound round with a cord: sometimes eight or nine of these mortars, of about three or four inches diameter, are bound all together, so as to appear but one: but when they are made for this purpose, the bottom of the foot must be of the same diameter as the mortars, and only half a diameter high. The mortars being bound well together, fix them on a heavy solid block of wood. To load these mortars, first put on the inside bottom of each a piece of paper, and on it spread one ounce and a half of meal and corn powder mixed; then tie the serpents up in parcels, with quick-match, and put them in the mortar with their mouths downwards; but take care the parcels do not fit too tight in the mortars, and that all the serpents have been well primed with powder wetted with spirit of wine. On the

top of the serpents in each mortar lay some paper or tow; then carry a leader from one mortar to the other all round, and then from all the outside mortars into that in the middle: these leaders must be put between the cases and the sides of the mortar, down to the powder at bottom; in the centre of the middle mortar fix a fire pump, or brilliant fountain, which must be open at bottom, and long enough to project out of the mouth of the mortar; then paste paper on the tops of all the mortars.

Mortars thus prepared are called a *nest of serpents*. When these mortars are to be fired, light the fire-pump, which when consumed will communicate to all the mortars at once by means of the leaders. For mortars of 8, 9, or 10 inches diameter, the serpents should be made in one and two ounce cases six or seven inches long, and fired by a leader brought out of the mouth of the mortar, and turned down on the outside, and the end of it covered with paper, to prevent the sparks of the other works from setting it on fire. For a six-inch mortar, let the quantity of powder for firing be two ounces; for an eight-inch, two ounces and three-quarters; and for a ten-inch, three ounces and three quarters. Care must be taken in these, as well as small mortars, not to put the serpents in too tight, for fear of bursting the mortars. These mortars may be loaded with stars, crackers, &c.

If the mortars, when loaded, are sent to any distance, or liable to be much moved, the firing powder should be secured from getting amongst the serpents, which would endanger the mortars, as well as hurt their performance. To prevent this, load the mortars thus: first put in the firing powder, and spread it equally about; then cut a round piece of blue touch-paper, equal to the exterior diameter of the mortar, and draw on it a circle equal to the interior diameter of the mortar, and notch it all round as far as that circle: then paste that part which is notched, put it down the mortar close to the powder, and stick the pasted edge to the mortar: this will keep the powder always smooth at bottom, so that it may be moved or carried anywhere without receiving damage. The large single mortars are called *pots des aigrettes*.

FIRE PUMPS, OR ROMAN CANDLES.

CASES for fire pumps are made as those for tourbillons; only they are pasted instead of being rolled dry. Having rolled and dried your cases, fill them: first put in a little meal-powder and then a star, on which ram, lightly, a ladle or two of composition, then a little meal-powder, and on that a star, then again composition, and so on till you have filled the case. Stars for fire-pumps should not be round, but must be made either square, or flat and circular, with a hole through the middle: the quantity of powder for throwing the stars must increase as you come near the top of the case; for, if much powder be put at the bottom, it will burst the case. The stars must differ in size in this manner: let the star which you put in first be a little less than the bore of the case; but let the next star be a little larger, and the third star a little larger than the second, and so on: let them increase in diameter till within two of the top of the case, which two must fit in tight. As the loading of fire pumps is somewhat difficult, it will be necessary to make two or three trials before you depend on their performance. When you fill a number of pumps, take care not to put in each an equal quantity of charge between the stars, so that when they are fired, they may not throw up too many stars together. Cases for fire-pumps should be made very strong, and rolled on 4 or 8 ounce formers, 10 or 12 inches long each.

CHARGE.

	lb.oz.	or,	lb.oz.
Saltpetre	5 0	Saltpetre	5 0
Brimstone	1 0	Brimstone.....	2 0
Meal-powder.....	1½ 0	Meal-powder	1 8
Glass-dust.....	1 0	Glass-dust.....	1 8

AN ARTIFICIAL EARTHQUAKE.

Mix the following ingredients to a paste with water, and then bury it in the ground, and in a few hours the earth will break open in several places.

	lb.oz.		lb.oz.
Sulphur.....	4 0	Steel-dust	4 0

Chinese Fountains.

To make a Chinese fountain, you must have a perpendicular piece of wood seven feet long and two inches and a half square. Sixteen inches from the top, fix on the front a cross piece one inch thick, and two and a half broad, with the broad side upwards; below this fix three or more pieces of the same width and thickness, at sixteen inches from each other; let the bottom rail be five feet long, and the others of such a length as to allow the fire-pumps to stand in the middle of the intervals of each other. The pyramid being thus made, fix in the holes made in the bottom rail five fire-pumps, at equal distances; on the second rail, place four pumps; on the third, three; on the fourth, two; and on the top of the post, one; but place them all to incline a little forward, that, when they throw out the stars, they may not strike against the cross rails. Having fixed your fire-pumps, clothe them with leaders, so that they may be all fired together.

The Dodecahedron.

So called because it nearly represents a twelve-sided figure, is made thus: first have a ball turned out of some hard wood, 14 inches diameter: divide its surface into 14 equal parts, from which bore holes one inch and a half diameter, perpendicular to the centre, so that they may all meet in the middle: then let there be turned in the inside of each hole a female screw; and to all the holes but one must be made a round spoke five feet long, with four inches of the screw at one end to fit the holes; then in the screw-end of all the spokes bore a hole, five inches up, which must be bored slanting, so as to come out at one side, a little above the screw; from which cut a small groove along the spoke, within six inches of the other end, where make another hole through to the other side of the spoke. In this end fix a spindle, on which put a small wheel of three or four sides, each side six or seven inches long; these sides must have grooves cut in them, large enough to receive a two or four ounce case. When these wheels are clothed, put them on spindles, and at the end of each

spindle put a nut to keep the wheel from falling off. The wheels being thus fixed, carry a pipe from the mouth of the first case on each wheel, through the hole in the side of the spoke, and from thence along the groove, and through the other hole, so as to hang out at the screw-end about an inch. The spokes being all prepared in this manner, you must have a post, on which you intend to fire the work, with an iron screw on the top of it, to fit one of the holes in the ball: on the screw fix the ball: then in the top hole of the ball put a little meal powder, and some loose quick-match: then screw in all the spokes; and in one side of the ball bore a hole, in which put a leader, and secure it at the end; and the work will be ready to be fired. By the leader the powder and match in the centre are fired, which will light the match at the ends of the spokes all at once, whereby all the wheels will be lighted at once. There may be an addition to this piece, by fixing a small globe on each wheel, or one on the top wheel only. A grey charge will be proper for the wheel cases.

Stars with Points.

THESE stars are made of different sizes, according to the work for which they are intended; they are made with cases from one ounce to one pound, but in general with four-ounce cases, four or five inches long: the case must be rolled with paste, and twice as thick as that of a rocket of the same bore. Having rolled a case, pinch one end of it quite close: then drive in half a diameter of clay; and when the case is dry, fill it with composition two or three inches to the length of the cases with which it is to burn: at top of the charge drive some clay; as the ends of these cases are seldom pinched, they would be liable to take fire. Having filled a case, divide the circumference of it at the pinched end close to the clay into five equal parts; then bore five holes with a gimlet about the size of the neck of a common four-ounce case, into the composition: from one hole to the other carry a quick-match, and secure it with paper: this paper must be put on in the manner of that on the end of wheel-cases, so that the hollow part,

which projects from the end of the case, may serve to receive a leader from any other work, to give fire to the points of the stars. These stars may be made with any number of points.

Fixed Sun with a transparent Face.

To make a sun of the best kind, there should be two rows of cases, which will show a double glory, and make the rays strong and full. The frame or sun-wheel must be made thus: have a circular flat nave made very strong, 12 inches diameter; to this fix six strong flat spokes: on the front of these fix a circular fell, five feet diameter; within which fix another fell, the length of one of the sun-cases less in diameter; within this fix a third fell, whose diameter must be less than the second by the length of one case and one-third. The wheel being made, divide the fells into so many equal parts as there are to be cases (which may be done from 24 to 44): at each division fix a flat iron staple; these staples must be made to fit the cases, to hold them fast on the wheel; let the staples be so placed, that one row of cases may lie in the middle of the intervals of the other.

In the centre of the block of the sun drive a spindle, on which put a small hexagonal wheel, whose cases must be filled with the same charge as the cases of the sun: two cases of this wheel must burn at a time, and begin with them on the fells. Having fixed on all the cases, carry pipes of communication from one to the other, as you see in the figure, and from one side of the sun to the wheel in the middle, and from thence to the other side of the sun. These leaders will hold the wheel steady while the sun is fixing up, and will also be a sure method of lighting both cases of the wheel together. A sun thus made is called a *brilliant sun*, because the wood work is entirely covered with fire from the wheel in the middle, so that there appears nothing but sparks of brilliant fire: but if you would have a transparent face in the centre, you must have one made of pasteboard of any size. The method of making a face is, by cutting out the eyes, nose, and mouth for the sparks of the wheel to appear through; but instead

of this face, you may have one painted on oiled paper, or Persian silk, strained tight on a hoop; which hoop must be supported by three or four pieces of wire at six inches distance from the wheel in the centre, so that the light of it may illuminate the face. By this method may be shown in the front of a sun, VIVAT REX, cut in pasteboard, or Apollo painted on silk; but, for a small collection, a sun with a single glory, and a wheel in front, will be most suitable. Half-pound cases, filled ten inches with composition, will be a good size for a sun of five feet diameter; but, if larger, the cases must be greater in proportion.

DETONATING WORKS.

WATERLOO CRACKERS.

TAKE a slip of cartridge paper, about three quarters of an inch in width, paste and double it; let it remain till dry, and cut it into two equal parts in length, (Nos. 1 and 2) according to the following pattern:

No. 1.	Glass.	S	Glass.	Glass.
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Take some of the glass composition and lay it across the paper as in the pattern, and put about a quarter of a grain of fulminating silver in the place marked S, and while the glass composition is moist, put the paper marked No. 2, over the farthest row of glass. Over all, paste twice over the part that covers the silver a piece of paper; let it dry, and when you wish to explode it, take hold of the two ends and pull them sharply from each other, and it will produce a loud report.

DETONATING GIRDLE.

Procure a piece of girth from 12 to 18 inches in length. Double it, and fold it down about $1\frac{1}{2}$ inch, similar to the fold of a letter, and then turn back one end of the girth, and it will form two compartments. Then take some gum and dissolve it in water, boil it till it is quite melted, and very thick; add coarse powdered glass, sufficient to make it into a very thick paste, place two upright rows of the

glass composition in the inside of one of the folds, about as wide as the thickness of a lath, and as high as a half-crown laid flat; and when they are dry, sew the first fold together on the edge, and then the second at the opposite end, so that one end may be open. Then in the centre of the two rows put about a grain of fulminating silver, and paste a piece of cotton or silk over it. Make a hole at each end of the girdle, and hang it to a hook in the door-post, and the other hook on the door, observing to place the silk part so that it may come against the edge of the door when opened, which will cause a report as loud as a small cannon. The fulminating silver may be purchased at any of the operative chemists.

DETONATING BALLS.

Procure some glass globes, between the size of a pea and a small marble, in which there must be a small hole; put into it half a grain of fulminating silver. Paste a piece of paper carefully over the ball to prevent the silver from escaping. When you wish to explode one, put it on the ground, and tread hard upon it, and it will go off with a loud noise. These balls may be made productive of much amusement in company, by placing a chair lightly on them, for whoever sits down upon them will cause them to explode. These globes may be procured at the barometer-makers'.

THE DETONATING TAPE.

Is made of binding, about three-fourths of an inch in width. Observe the same directions as given for the girdle; you may either explode it yourself, by taking hold of each end, and rolling the ends from each other sharply, or give one end to another, and pull together.

DETONATING CARDS.

Take a piece of card about three-fourths of an inch in breadth and 12 in length; slit it at one end, and place in the opening a quarter of a grain of fulminating silver; close the edges down with a little paste, and when dry you may use it, by lighting the end in the candle.

Having given the method by which these loud reports are produced, we shall mention some other effects to be pro-

duced by the silver, capable of affording much amusement. For instance, by placing about a quarter of a grain of the silver in the middle of some tobacco in a pipe, or between the leaves of a segar, and closing the end again to prevent the powder from falling out; when lighted, it causes a loud explosion, for heat, as well as friction, will equally do.

Or, take one-third of a grain of fulminating silver; fold it up in a small piece of paper, and wrap it up in another piece, and paste it round a pin. These pins stuck in the wick of a candle make a very loud noise.

Fulminating silver may be also used in the following manner:—Put half a grain in a piece of glass paper, and inclose it in a piece of foil; put it then at the bottom or side of a drawer, and on opening or shutting it, it will immediately go off.

Put a quarter of a grain of fulminating silver into a piece of paper, and place it in the snuffers when quite cold; when the candle is snuffed it will go off.

AQUATIC FIREWORKS.

Works that sport in the water are much esteemed by most admirers of fire-works, particularly water-rockets; and as they seem of a very extraordinary nature to those who are unacquainted with this art, they merit a particular explanation.

Water Rockets.

THEY may be made from four ounces to two pounds. If larger, they are too heavy; so that it will be difficult to make them keep above water without a cork float, which must be tied to the neck of the case; but the rockets will not dive so well with as without floats.

Cases for these are made in the same manner and proportion as sky-rockets, only a little thicker of paper. when you fill those which are driven solid, put in first one ladleful of slow fire, then two of the proper charge, and on that one or two ladles of sinking charge, then the proper charge, then the sinking charge again, and so on, till

you have filled the case within three diameters ; then drive on the composition one ladleful of clay ; through which make a small hole to the charge ; then fill the case within half a diameter, with corn-powder, on which turn down two or three rounds of the case in the inside ; then pinch and tie the end very tight ; having filled the rockets (according to the above directions), dip their ends in melted rosin or sealing-wax, or else secure them well with grease. When you fire those rockets, throw in six or eight at a time ; but, if you would have them all sink, or swim, at the same time, you must fill them with an equal quantity of composition, and fire them altogether.

Pipes of Communication for Water.

THEY may be used under water, but must be a little thicker in the paper than those for land. Having rolled a sufficient number of pipes, and kept them till dry, wash them over with drying oil, and set them to dry ; but when you oil them, leave about an inch and a half at each end dry, for joints ; as, if they were oiled all over, when you come to join them, the paste would not stick where the paper is greasy ; after the leaders are joined, and the paste dry, oil the joints. These pipes will lie many hours under water, without receiving any damage.

Horizontal Water-Wheels.

To make horizontal wheels for the water, first get a large wooden bowl without a handle ; then have an eight-sided wheel made of a flat board 18 inches diameter, so that the length of each side may be nearly seven inches ; in all the sides cut a groove for the cases to lie in. This wheel being made, nail it on the top of the bowl ; then take four eight-ounce cases, filled with a proper charge, each about six inches in length. Now, to clothe the wheel with these cases, get some whitish-brown paper, and cut it into slips four or five inches broad and seven or eight long ; these slips being pasted all over on one side, take one of the cases, and roll one of the slips of paper about an inch and a half

on its end, so that there will remain about two inches and a half of the paper hollow from the end of the case : tie this case on one of the sides of the wheel, near the corners of which must be holes bored, through which put the pack-thread to the cases : having tied on the first case at the neck and end, put a little meal-powder in the hollow paper ; then paste a slip of paper on the end of another case, the head of which put into the hollow paper on the first, allowing a sufficient distance from the tail of one to the head of the other for the pasted paper to bend without tearing : tie on the second case as you did the first : and so on with the rest, except the last, which must be closed at the end, unless it is to communicate to any thing on the top of the wheel, such as fire-pumps or brilliant fires, fixed in holes cut in the wheel, and fired by the last or second case, as the fancy directs : six, eight, or any number, may be placed on the top of the wheel, provided they be not too heavy for the bowl.

Before tying on the cases, cut the upper part of all their ends, except the last, a little shelving, that the fire from one may play over the other, without being obstructed by the case. Wheel carriages have no clay driven in their ends, nor pinched, but are always left open, only the last, or those which are not to lead fire, which must be well secured.

Water-Mines.

FOR water mines you must have a bowl with a wheel on it, made in the same manner as the water-wheel ; only in its middle there must be a hole, of the same diameter as that of the intended mine. These mines are tin-pots, with strong bottoms, and a little more than two diameters in length ; the mine must be fixed in the hole in the wheel, with its bottom resting on the bowl ; then loaded with serpents, crackers, stars, small water-rockets, &c. in the same manner as pots of aigrettes ; but in their centre fix a case of Chinese fire, or a small gerbe, which must be lighted at the beginning of the last case on the wheel. These wheels are to be clothed as usual.

Fire-Globes for the Water.

BOWLS for water-globes must be very large, and the wheels on them of ten sides: on each side nail a piece of wood four inches long; and on the outside of each piece cut a groove, wide enough to receive about one-fourth of the thickness of a four-ounce case: these pieces of wood must be nailed in the middle of each face of the wheel, and fixed in an oblique direction, so that the fire from the cases may incline upwards: the wheel being thus prepared, tie in each groove a four-ounce case filled with a grey charge; then carry a leader from the tail of one case to the mouth of the other.

Globes for these wheels are made of two tin hoops, with their edges outwards, fixed one within the other, at right angles. The diameter of these hoops must be rather less than that of the wheel. Having made the globe, drive in the centre of a wheel an iron spindle, which must stand perpendicular, and its length be four or six inches more than the diameter of the globe.

The spindle serves for an axis, on which is fixed the globe, which must stand four or six inches from the wheel: round one side of each hoop must be soldered little bits of tin, two inches and a half distance from each other; which pieces must be two inches in length each, and only fastened at one end, the other ends being left loose, to turn round the small portfires, and hold them on: these portfires must be made of such a length as will last out the cases on the wheel. There need not be any portfires at the bottom of the globe within four inches of the spindle; as they would have no effect, but to turn the wheel: all the portfires must be placed perpendicularly from the centre of the globe, with their mouths outwards; and must be clothed with leaders, so as all to take fire with the second case of the wheel; and the cases must burn two at a time, one opposite the other. When two cases of a wheel begin together, two will end together; therefore the two opposite end cases must have their ends pinched and secured from fire. The method of firing such wheels is, by carrying a leader from the mouth of one of the first cases to that of the other; and the leader being burnt through the middle, will give fire to both at the same time.

Odoriferous Water-Balloons.

THEY are made in the same manner as air-balloons, but of very thin paper, and in diameter one inch and three-fourths, with a vent of half an inch diameter. The shells being made, and quite dry, fill them with any of the following compositions, which must be rammed in tight; these balloons must be fired at the vent, and put into a bowl of water. Odoriferous works are generally fired in rooms.

Composition I. Saltpetre two ounces, flour of sulphur one ounce, camphor half an ounce, yellow amber half an ounce, charcoal-dust three-fourths of an ounce, salt of benjamin half an ounce, all powdered very fine and well mixed.

II. Saltpetre twelve ounces, meal-powder three ounces, frankincense one ounce, myrrh half an ounce, camphor half an ounce, charcoal three ounces, all moistened with the oil of spike.

III. Saltpetre two ounces, sulphur half an ounce, antimony half an ounce, amber half an ounce, cedar raspings one-fourth of an ounce, all mixed with the oil of roses and a few drops of bergamot.

IV. Saltpetre four ounces, sulphur one ounce, saw-dust of Juniper half an ounce, saw-dust of cypress one ounce, camphor one-fourth of an ounce, myrrh two drams, dried rosemary one-fourth of an ounce, all moistened a little with the oil of roses.

N. B. Water-rockets may be made with any of the above compositions, with a little alteration, to make them weaker or stronger, according to the size of the cases.

A Sea-fight with small Ships and a Fire-Ship.

HAVING procured four or five small ships, of two or three feet in length, make a number of small reports, which are to serve for guns. Of these range as many as you please on each side of the upper decks; then at the head and stern of each ship fix a two-ounce case, eight inches long, filled with a slow portfire composition; but take care to place it in such a manner that the fire may fall in the water, and not burn the rigging: in these cases bore holes at unequal distances

from one another, but make as many in each case as half the number of reports, so that one case may fire the guns on one side, and the other those on the opposite. The method of firing the guns is, by carrying a leader from the hoks in the cases to the reports on the decks; you must make these leaders very small, and be careful in calculating the burning of the slow fire in the regulating cases, that more than two guns be not fired at a time. When you would have a broadside given, let a leader be carried to a cracker, placed on the outside of the ship; which cracker must be tied loose, or the reports will be too slow: in all the ships put artificial guns at the port-holes. Reports for these and similar occasions are made by filling small cartridges with grained powder, pinching them close at each end, and, when used, boring a hole in the side, to which is placed a match or leader for firing them.

Having filled and bored holes in two port-fires for regulating the guns in one ship, make all the rest exactly the same; then, when you begin the engagement, light one ship first, and set it a sailing, and so on with the rest, sending them out singly, which will make them fire regularly, at different times, without confusion; for the time between the firing of each gun will be equal to that of lighting the slow fires.

The fire-ship may be of any size; and need not be very good, for it is always lost in the action. To prepare a ship for this purpose, make a port-fire equal in size with those in the other ships, and place it at the stern; in every port place a large port-fire, filled with a very strong composition, and painted in imitation of a gun, and let them all be fired at once by a leader from the slow fire, within two or three diameters of its bottom; all along both sides, on the top of the upper deck, lay star-composition about half an inch thick and one broad, which must be wetted with thin size, then primed with meal-powder, and secured from fire by pasting paper over it; in the place where you lay this composition, drive some little tacks with flat heads, to hold it fast to the deck: this must be fired just after the sham guns; and when burning, will show a flame all round the ship: at the head take up the decks, and put in a tin mortar loaded with crackers, which mortar must be fired by a

pipe from the end of the slow fire; the firing of this mortar will sink the ship, and make a pretty conclusion. The regulating port-fire of this ship must be lighted at the same time with the first fighting ship.

Having prepared all the ships for fighting, we shall next proceed with the management of them when on the water. At one end of the pond, just under the surface of the water, fix two running blocks, at what distance you choose the ships should fight; and at the other end of the pond, opposite to each of these blocks, under the water, fix a double block; then on the land, by each of the double blocks, place two small windlasses; round one of them turn one end of a small cord, and put the other end through one of the blocks; then carry it through the single one at the opposite end of the pond, and bring it back through the double block again, and round the other windlass: to this cord, near the double block, tie as many small strings as half the number of the ships, at any distance; but these strings must not be more than two feet long each: make fast the loose end of each to a ship, just under her bowsprit; for if tied to the keel, or too near the water, it will overset the ship. Half the ships being thus prepared, near the other double block fix two more windlasses, to which fasten a cord, and to it tie the other half of the ships as before: when you fire the ships, pull in the cord with one of the windlasses, to get all the ships together; and when you have set fire to the first, turn that windlass which draws them out, and so on with the rest, till they are all out in the middle of the pond; then, by turning the other windlass, you will draw them back again; by which method you may make them change sides, and tack about backward and forward at pleasure. For the fire-ship fix the blocks and windlasses between the others; so that when she sails out, she will be between the other ships: you must not let this ship advance till the guns at her ports take fire.

To fire Sky-Rockets under Water.

You must have stands made as usual, only the rails must be placed flat instead of edgewise, and have holes in them

for the rocket-sticks to go through; for if they were hung upon hooks, the motion of the water would throw them off: the stands being made, if the pond is deep enough, sink them at the sides so deep, that, when the rockets are in, their heads may just appear above the surface of the water; to the mouth of each rocket fix a leader, which put through the hole with the stick; then a little above the water must be a board, supported by the stand, and placed along one side of the rockets; then the ends of the leaders are turned up through holes made in this board, exactly opposite the rockets. By this means you may fire them singly or all at once. Rockets may be fired by this method in the middle of a pond, by a Neptune, a swan, a water-wheel, or any thing else you choose.

Neptune in his Chariot.

To represent Neptune in his chariot, you must have a Neptune (made of wood, or basket work) as big as life, fixed on a float large enough to bear his weight; on which must be two horses' heads and necks, so as to seem swimming. For the wheels of the chariot, there must be two vertical wheels of black fire, and on Neptune's head a horizontal wheel of brilliant fire, with all its cases, to play upwards. When this wheel is made, cover it with paper or pasteboard, cut and painted like Neptune's coronet; then let the trident be made without prongs, but instead of them fix three cases of a weak grey charge, and on each horse's head put an eight-ounce case of brilliant fire, and on the mouth of each fix a short case, of the same diameter, filled with the white-flame composition enough to last out all the cases on the wheels: these short cases must be open at bottom, that they may light the brilliant fires; for the horses' eyes put small port-fires, and in each nostril put a small case half filled with grey charge, and the rest with port-fire composition.

If Neptune is to give fire to any building on the water; at his first setting out, the wheels of the chariot, and that on his head, with the white flames on the horses' heads, and the port-fires in their eyes and nostrils, must all be lighted at once; then from the bottom of the white flames

carry a leader to the trident. As Neptune is to advance by the help of a block and cord, you must manage it so as not to let him turn about, till the brilliant fires on the horses and the trident begin; for it is by the fire from the horses (which plays almost upright) that the building, or work, is lighted; which must be thus prepared. From the mouth of the case which is to be first fired, hang some loose quick-match to receive the fire from the horses. When Neptune is only to be shown, by himself, without setting fire to any other works, let the white flames on the horses be very short, and not to last longer than one case of each wheel, and let two cases of each wheel burn at a time.

Swans and Ducks in Water.

If you would have swans or ducks discharge rockets into the water, they must be made hollow, and of paper, and filled with small water rockets, with some blowing powder to throw them out: but if this is not done, they may be made of wood, which will last many times. Having made and pointed some swans, fix them on floats: then in the places where their eyes should be, bore holes two inches deep, inclining downwards, and wide enough to receive a small port-fire; the port-fire cases for this purpose must be made of brass, two inches long, and filled with a slow bright charge. In the middle of one of these cases make a little hole; then put the port-fire in the eye-hole of the swan, leaving about half an inch to project out; and in the other eye put another port-fire, with a hole made in it: then in the neck of the swan, within two inches of one of the eyes, bore a hole slantwise, to meet that in the port-fire; in this hole put a leader, and carry it to a water-rocket, that must be fixed under the tail with its mouth upwards. On the top of the head place two one-ounce cases, four inches long each, driven with brilliant fire; one of these cases must incline forwards, and the other backwards: these must be lighted at the same time as the water-rocket; to do which, bore a hole between them in the top of the swan's head, down to the hole in the port-fire, to which carry a leader: if the swan is filled with rockets, they must be fired

by a pipe from the end of the water-rocket under the tail. When you set the swan a swimming, light the two eyes.



Water Fire-Fountains.

To make a fire-fountain for the water, first have a float made of wood, three feet diameter; then in the middle fix a round perpendicular post, four feet high, and two inches diameter; round this post fix three circular wheels made of thin wood, without any spokes. The largest of these wheels must be placed within two or three inches of the float, and must be nearly of the same diameter. The second wheel must be two feet two inches diameter, and fixed at two feet distance from the first. The third wheel must be one foot four inches diameter, and fixed within six inches of the top of the post: the wheels being fixed, take 18 four or eight-ounce cases of brilliant fire, and place them round the first wheel with their mouths outwards, and inclining downwards; on the second wheel place 13 cases of the same, and in the same manner as those on the first; on the third, place eight more of these cases, in the same manner as before, and on the top of the post fix a gerbe; then clothe all the cases with leaders, so that both they and the gerbe may take fire at the same time. Before firing this work, try it in the water to see whether the float is properly made so as to keep the fountain upright.

THE END.

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